

Chemistry of cream

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CREAM

Cream is that portion of milk, rich in milk fat that rises to the top of milk while it is standing or it is separated by centrifugation of milk. According to FSSA (2006), cream excluding sterilized cream means the product of cow or buffalo milk or a combination thereof. It shall be free from starch and other ingredients to foreign milk. It may be of following three categories, namely:-

- a. Low fat cream- containing milk fat not less than 25.0 percent by weight
 - b. Medium fat cream- containing milk fat not less than 40.0 percent by weight
 - c. High fat cream- containing milk fat not less than 60.0 percent by weight
- Cream sold without any indication about milk fat content shall be treated as high fat cream

Although the proportion of the fat present in cream varies greatly, the relative proportion of the other ingredients remain almost same as in the milk from which the cream was derived.

Approximate composition (%) of Cream

Constituents	Light cream	Heavy Cream
Fat	19 – 21	35 – 40
Protein	2.5 – 3.0	1.9 – 2.3
Casein	1.9 – 2.3	1.5 – 1.8
Whey protein	0.5 – 0.6	0.4 – 0.5
Carbohydrate	3.6 – 4.2	2.6 – 3.2
Ash	0.5 – 0.7	0.4 – 0.5
Lactic acid	Trace	Trace

Chemistry of Creaming Process

The basic principle of cream separation lies in the differences in the specific gravity of milk fat and milk serum (skim milk).

Two methods are available for the fat separation, i.e Gravity method and Mechanical method

Gravity Method

Normal milk will form a cream layer within 20-30 minutes. Complete formation of this cream layer may take several hours. This phenomenon involves properties of the fat globules, such as clustering. Broadly speaking, the fat globules rise according to Stoke's law. However, average fat globule of approximate 4μ diameter would take several hours to rise 1 inch according to Stoke's law. Therefore other factor must be involved to produce a cream layer within 30 minutes.

Now Stoke's law:

$$V = \frac{2gr^2 (d_1 - d_2)}{9\eta}$$

Where,

V = velocity of rise in cm/sec

r = radius of spheres in cm (fat globule)

d_1 = density of dispersion medium (skim milk)

d_2 = density of the sphere (fat globule)

g = Acceleration due to gravity (981 dynes)

η = viscosity of liquid in poises

From Stoke's law, it is observed, theoretically that the velocity is increased by:

- 1). Increase in radius of fat globule
- 2) In differences in densities of skim milk and fat
- 3). Decrease in the viscosity of skim milk

The principle factor that aids the creaming process is clustering of individual globules. As the milk is drawn from the udder, the globules exist largely as separate entities. In few moments, the globules in milk begin to rise. The velocity of rise is directly proportional to the square of the radius of globules. Therefore larger globules overtake the smaller one rather quickly. At this point, the factor of clustering comes in play, when a large globule comes in contact with a smaller globule, it is held there and two joined globule rise together at an even more rapid rate primarily because of their greater effective radius. Incidental to their rise they

come in contact with other globule until cluster of substantial size are formed, which rise much more rapidly than any other individual globule. These clusters do not rise strictly accordingly to stoke's law, since they are irregular in shape and contain considerable occluded serum.

Agglutinin (complex of cryoglobulins, predominantly immunoglobulin and lipoprotein) in the milk is essential to clustering of fat globules and formation of normal cream layer. This agglutinating substance is absorbed on the surface of the solid or solidifying fat globule but not on the liquid globule. Therefore greater clustering occurs at low temperature. Another explanation set forth is an electrical theory of fat clustering. The presence of large quantity of calcium ion imparts some positive charge to the weak negatively charge fat globule and creates electrical affinity between the globules. An optimum concentration of salts is necessary to favour the clustering of fat by euglobulin.

In general, good clustering means a good recovery of the fat and a deep cream layer with low fat in the skim milk.

Factors affecting the creaming process

The important factors affecting the rate of rise of cream are as follows:

Size of fat globule

As the size of the fat globule increases the rate at which cream rise also increase. Thus in buffalo milk gravity cream occurs faster due to the larger size of the fat globule than those in cow milk.

Temperature:

Cooling of milk to low temperature (0 – 5⁰C) promotes the formation of deep cream layer. Creaming does not occur above 37⁰C .In heating process all the agglutinin is desorbed from the fat globule surface and on cooling condition can be made optimum for reabsorption process.

Agitation:

Excessive agitation should be avoided because of its disrupting effect on normal cluster formation and the possibility of its denaturing agglutinin.

The creaming process in cold milk may actually be facilitated by mild agitation, since such treatment would favour larger cluster, which would be more loosely packed.

Composition of milk:

Higher the fat content of milk, the quicker the creaming is because formation of floccules is quicker.

Heat treatment

Agglutinin and creaming are impaired or prevented by heating owing to denaturation of cryoglobulins. Heating for 20 seconds at 71⁰C has no effect and 78⁰C often leads to complete inactivation..

Homogenization:

Homogenization breaks up the fat globules to about one-fourth of their original size and no creaming results due either to these small globules or to the denaturing effect of homogenization on the globulin fraction.

Additives

Addition of thickening agent, usually polysaccharides like locust bean gum or carboxymethyl cellulose or k-carrageenan slow down creaming, because they may form (either alone or in combination with casein micelles) a weak network that entraps the fat globules. Cream rising is then virtually absent.

Mechanical Method

When milk enters the rapidly revolving bowl of the cream separator, it is immediately subjected to a tremendous centrifugal force. As the bowl revolves, the cream being lighter than skim milk, is driven by centrifugal force towards the centre of bowl, while skim milk is driven outwards (periphery).

For creaming in a centrifugal field stoke's law still holds but acceleration due to gravity is replaced by centrifugal force W^2R , where W is the centrifugal speed in radians/see (2π radius = 3600) and R is the distance (cm) of the particle from the axis of rotation.

$$W^2R = \frac{(2\pi S)^2}{(60)^2} R$$

Where S is the bowl speed in r.p.m. inserting this value for g in stoke's equation

$$V = \frac{0.00244 (d_1 - d_2) r^2 s^2 R}{N}$$

Thus the rate of separation is influenced by the radius of fat globules, the radius and speed of separation, the difference in density of the continuous and dispersed phase and the viscosity of milk.

Fat globules smaller than 2μ in diameters are not separated efficiently. The separator may be adjusted so that the ratio of the volume of skim milk to cream is constant. Thus permitting separation of cream of a desired fat content from milk of a given fat content. The efficiency of separation increases with temperature, especially in the range of $20 - 40^\circ\text{C}$.

Cream Powder

Cream powder means the products obtained by partial removal of water from cream obtained from milk of cow and / or buffalo. The fat and / or protein content of the cream may be adjusted by addition and / or withdrawal of milk constituents in such a way as not to alter the whey protein to casein ratio of the milk adjusted. It shall be of uniform colour and shall have pleasant taste and flavour, free from off flavour and rancidity . It shall be free from vegetable oil/fat, mineral oil, added flavour and substance foreign to milk . It shall conform the following chemical requirements :-

Moisture	Not more than 5.0 percent
Milk fat	Not less than 42.0 percent
Milk protein in Milk soild not fat	Not less than 34.0 percent